

microchannel distillation sections (410, 410a) comprises a first process microchannel (420, 420a), a second process microchannel (425, 425a), a first vapor channel (435, 435a), a second vapor channel (440, 440a), and a third vapor channel (445, 445a). Microchannel distillation section 410 includes vapor inlet/outlets 450 and 452. The vapor outlet 452 also functions as a vapor inlet for microchannel distillation section 410a. Microchannel distillation section 410a includes vapor inlet/outlets 452 and 454. The process microchannels (420, 425, 420a, 425a) are adjacent to liquid channel 415. Part of the wicking region 416 functions as a wall (421, 426, 421a, 426a) for the process microchannels (420, 425, 420a, 425a). While not wishing to be bound by theory, it is believed that capillary forces in the wicking region (416) maintain a separation between the liquid phase in the wicking region (416) and the vapor phase in the adjacent process microchannels (420, 425, 420a, 425a), while still allowing for mass transfer to occur at the interface between the wicking region and the process microchannels. The lower interior first vapor channels (435, 435a) are adjacent to the lower process microchannels (420, 420a). The upper interior third vapor channels (445, 445a) are adjacent to the upper process microchannels (425, 425a). The outer second vapor channels (440, 440a) are adjacent to the inner first and third vapor channels (435, 445, 435a, 445a). Heat exchange channel 470 is adjacent to the outer vapor channels 440 and 440a, and heat exchange channel 475 is adjacent to liquid channel 415. It will be understood that if the microchannel distillation unit 400 is repeated in a microchannel distillation column, each repetition of the microchannel distillation unit 400 will share a heat exchange channel with the next adjacent microchannel distillation unit 400, thus each repetition of the microchannel distillation unit 400 will have one heat exchange channel. For example, the heat exchange channel 470 of one microchannel distillation unit 400 will also function as the heat exchange channel 475 of the next adjacent microchannel distillation unit 400. The first and third vapor channels (435, 445, 435a, 445a) and the second vapor channels (440, 440a) may be positioned in different planes as illustrated in FIG. 7, or they may be positioned side by side in the same plane. In regions where the second vapor channel (440, 440a) and the first vapor channel (435, 435a) or third vapor channel (445, 445a) appear to cross over one another in FIG. 7, the flow of the vapor phase streams may be maintained in separate planes. For example, the streams shown flowing horizontally in FIG. 7 may flow above the plane of the page, while the streams shown flowing vertically in FIG. 7 may flow below the plane of the page. These streams may be sealed from crossing the plane of the page in such a way as to prevent vapor flow from bypassing any of the microchannel distillation sections (410, 410a). Each of the microchannel distillation sections (410, 410a) contains junctions (423, 428, 423a, 428a) wherein the vapor phase contacts a wall which forms a seal with the liquid phase in the wicking region 416. This seal in combination with capillary forces in the wicking region 416 may prevent vapor from intruding into the wicking region 416 or from bypassing any of the microchannel distillation sections (410, 410a).

[0063] In operation, a liquid phase containing components X and Y flows downwardly through the wicking region 416 in the liquid channel 415, as indicated by arrows 417. A vapor phase containing components X and Y flows through vapor inlet/out 450, as indicated by arrow 451, into and

through first vapor channel 435 as indicated by arrow 436, and into and through process microchannel 420, as indicated by arrow 422. In the process microchannel 420 the vapor phase contacts at least part of the liquid phase in the wicking region 416. Part of the more volatile component Y transfers from the liquid phase to the vapor phase to form a component Y rich vapor phase. Part of the less volatile component X transfers from the vapor phase to the liquid phase to form a component X rich liquid phase. The vapor phase flows from process microchannel 420 to and through second vapor channel 440, as indicated by arrows 441, and from second vapor channel 440 into and through process microchannel 425, as indicated by arrow 427. In the process microchannel 425, the vapor phase contacts at least part of the liquid phase in the wicking region 416. Part of the more volatile component Y transfers from the liquid phase to the vapor phase to form a component Y rich vapor phase. Part of the less volatile component X transfers from the vapor phase to the liquid phase to form a component X rich liquid phase. The vapor phase flows from process microchannel 425 to and through third vapor channel 445, as indicated by arrow 446, and then to and through vapor inlet/outlet 452, as indicated by arrow 453. The vapor phase flows from vapor inlet/outlet 452 into and through first vapor channel 435a, as indicated by arrow 436a, into and through process microchannel 420a, as indicated by arrow 422a. In the process microchannel 420a, the vapor phase contacts at least part of the liquid phase in the adjacent wicking region 416. Part of the more volatile component Y transfers from the liquid phase to the vapor phase to form a component Y rich vapor phase. Part of the less volatile component X transfers from the vapor phase to the liquid phase to form a component X rich liquid phase. The vapor phase flows from the process microchannel 420a to and through the second vapor channel 440a, as indicated by arrow 441a, and then to and through process microchannel 425a, as indicated by arrow 427a. In the process microchannel 425a, the vapor phase contacts at least part of the liquid phase in the wicking region 416. Part of the more volatile component Y transfers from the liquid phase to the vapor phase to form a component Y rich vapor phase. Part of the less volatile component X transfers from the vapor phase to the liquid phase to form a component X rich liquid phase. The vapor phase flows from the process microchannel 425a to and through the third vapor channel 445a, as indicated by arrow 446a, and to and through vapor inlet/outlet 454, as indicated by arrow 455. The flow of the vapor phase through the microchannel distillation sections (410, 410a) may be driven by a static pressure differential. The flow of the liquid phase through the wicking region 416 may be driven by one or more of gravity, shear force from the vapor phase flowing through the process microchannels (420, 425, 420a, 425a), capillary forces in the wicking region 416, and a pressure differential within liquid held in the wicking region 416 by capillary forces (e.g., inducing flow from the wicking region 416 by suction after the liquid phase in the wicking region 416 separates from the vapor phase in the process microchannels (420, 425, 420a, 425a) and is cooled).

[0064] The flow of heat exchange fluid through heat exchange channel 470 may be co-current, cross-current or counter-current relative to the flow of vapor through the second vapor channels (440, 440a). The flow of heat exchange fluid through heat exchange channel 475 may be co-current, cross-current or counter-current relative to the